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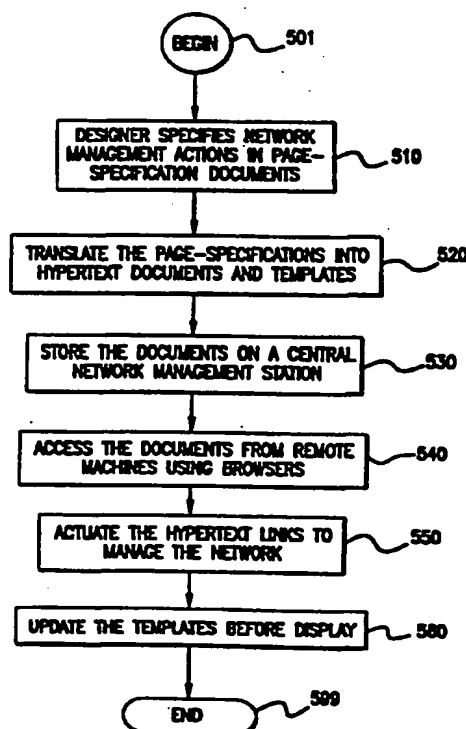
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(54) Title: NETWORK MANAGEMENT USING BROWSER-BASED TECHNOLOGY

(57) Abstract

A network management system (100) which enables a user to manage a network using browser available on remote computer systems (170). A designer provides a page specification document (510) identifying information elements of interest and corresponding explanatory labels. The page specification document (510) is translated into a plurality of hypertext documents. The page specification document also allows the designer to logically group (520) the information elements of interest, and the grouping automatically defines the sequence in which the hypertext documents (520) are accessed from other hypertext documents by actuating hypertext links in the other hypertext documents. The user interface is further simplified by providing Java Applets (1030), which provide a simple user interface.



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Network Management Using Browser-Based Technology

Background of the Invention

Field of the Invention

5 The present invention relates generally to network management, and more particularly to a system and method for managing network elements using web browsers available in the market place.

Related Art

10 Computer systems are often connected using networks. The resulting connectivity enables several features such as sharing of data and other resources on the network. For example, networks enable applications such as electronic mail, network file systems (sharing of data using disks accessed over networks), distributed processing (different computer systems executing different parts of a program, generally in parallel) and sharing of printers. These applications usually result in enhanced communication capabilities, efficient use of resources, and/or
15 faster processing of data, thereby leading to productivity gains.

20 Provision of network connectivity and applications generally entails the operation of several network elements implemented according to predefined interfaces. Network elements include, but are not limited to, hardware circuits/devices and software entities (e.g., a process or a thread) which may operate according to interface specifications to provide the network connectivity or applications. The interfaces may be based on open standards such as Transmission Control Protocol/Internet Protocol (TCP/IP) and IEEE 802 family of protocols commonly used in the Internet Community, or proprietary standards such as System Network Architecture (SNA) implemented mostly in IBM
25 computing environments.

Proper management of such networks may be critical in the provision of network connectivity and applications. In general, network management can include several functions such as network monitoring (e.g., to ensure the proper operation of network elements in the network), performance management (e.g.,
5 to ensure performance bottlenecks are within acceptable levels), software distribution etc. The proper operation of each network element may be critical in a networking environment as the malfunctioning of (or performance bottleneck in) any network element in the path between two computer systems (or any two network resources) may adversely impact the applications and services between
10 the two computer systems. As the network elements are typically shared (or used) by several (potentially in the range of thousands) computer systems, many of them located in remote networks, the performance bottlenecks are often of great concern to managers/operators of computer systems and networks. In addition, as each network element may execute using different revisions or versions of
15 software, it may be important to ensure that all network elements operate using software versions which can operate cooperatively in a desired manner.

Network management stations (NMS) implementing network management functions are employed to manage the networks. Typically, network operators manage the network using a suitable interface (generally graphical user interface
20 based) on a NMS. The NMS indicates by a suitable alarm any problems with or changes in the status of the network. The operator may take appropriate corrective action with or without using the NMS.

The network management task is often complicated by the fact that each of the network elements may be provided by several vendors. The network
25 elements may simply need to conform to a pre-defined interface (or standard) to operate as a part of an integrated network. While the availability of each network element from multiple vendors may lead to reduction in prices, the management

of networks having network elements from several different vendors poses additional challenges to network managers.

5 For example, some vendors may allow their network elements to be managed from proprietary platforms only. Some vendors may support standards based network management applications (e.g., Simple Network Management Protocol), but the integration of the management of their devices into an NMS often requires extensive training. For example, the installation of the software to work with an NMS may require training from the vendor. Operators may need more training for providing on-going support. Such training may need to be
10 provided each time a new network element is added to the network. In addition, substantial effort may be required on the part of the vendors to develop software which runs on the NMS. The resulting overhead due to the development and training required may be unacceptable in certain situations.

15 Therefore, what is needed is a network management solution which allows easy integration of additional devices. The solution must also be usable by operators without requiring significant training.

20 There are yet more challenges encountered while managing networks that typically span multiple organizations and distant geographies. A network manager/operator may wish to monitor the status of a remote network. As will be appreciated, it is often impractical to install or provide the software for managing each network element on all remote sites. In addition, a manager/operator may wish to monitor the remote network from any of several machines. A manager may further wish to know the events which may have occurred prior to the precipitation of a problem.

25 Therefore, what is also needed is a network management solution which allows a person to easily monitor a remote network, preferably from several

machines. The network management solution should also allow the person to know significant events which may have occurred around (before and after) the time a problem has precipitated in the network. This knowledge may facilitate easier problem resolution.

5

Summary of the Invention

The present invention is directed to a system and method for managing networks using browsers. Specifically, an embodiment of the present invention is implemented on a central network management station and a user can manage the network from any remote computer system implementing a browser. Various Applets and Hypertext documents are provided by the present invention which are accessed using the browser. By simply clicking on the Applet displays and the hypertext links in the Hypertext documents, the user can manage the network. Thus, the management of the network is simplified. The concepts of browsers, Applets and hypertext documents as relevant to the present invention are explained in the section entitled "Detailed Description of the Preferred Embodiments" below.

10

The integration of new network elements into the network management system is simplified in accordance with the present invention. The present invention is best understood by explaining the manner in which new devices are integrated into the network management system. Accordingly, the integration of new devices (or network elements in general) is explained below first. In the description herein, network elements include, but not limited to, hardware devices and software entities as explained in further detail below.

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To integrate a new network element into the network management system of the present invention, a designer provides a page specification document. The page specification document includes an identification of information elements of

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interest and corresponding understandable labels. An information elements of interest is best understood by an example. A user may wish to know the number of bytes received on a particular interface of a router. Such a number is referred to as an information element of interest. In one embodiment, the information elements are identified by Management Information Base Object Identifiers (MIB
5 OIDs) well known in the art. The page specification document also defines a grouping of the different information elements of interest.

The page specification document is automatically translated into a plurality of hypertext documents. A document is associated with the hypertext links in
10 other documents, and the associated document is accordingly displayed when the hypertext links are actuated from the browser. Thus, the hypertext links define a plurality of sequences in which the hypertext documents can be accessed. The grouping of various information elements of interest in turn determines the sequence in which the documents are accessed as will be clearer from the detailed
15 description. The sequence is implemented by storing each document as a file, and specifying the file identifier as an (URL) associated with the hypertext link as is well known in the art. As the access sequence is defined by the grouping specified by the designer, the designer controls the manner in which different hypertext documents are accessed.

20 The hypertext documents generated from the translation also include 'templates', which are hypertext documents including dynamic fields. Dynamic fields refer to fields storing and displaying data corresponding to an information element of interest retrieved dynamically and displayed to the user. Thus, each dynamic field is associated with one or more corresponding identifiers (e.g.,
25 Management Information Base Object Identifier) for an information element of interest. Using these identifiers, data is retrieved dynamically upon user request and appropriately combined or modified before display to the user. In one

10 After receiving identifiers of the template and the subject network element, the network management station assembles SNMP get packets using the MIB
15 OIDs associated with the dynamic fields, and sends the packets to the subject network element. In response, the subject network element sends the requested data. The network management station integrates the received data into the
20 template and sends it back to the browser which displays the template including the received data. The user is also allowed to change the configuration of network elements by modifying or adding or deleting the received data provided such
25 access is permitted. Thus, the user can both monitor the network status and perform configuration management.

20 In the above description, a user may be required to manually provide the identifier of the subject network element for retrieving the data dynamically. This may not be convenient for the user. To obviate such a need, the present invention provides an Applet based interface as further described below.

25 In the Applet based interface, a network map is displayed. Each network element is given a label as specified by a designer. The user simply clicks on the network element in the map to manage the element. When the user clicks on a

network element, the network management station sends a starting hypertext document (also referred to as the home page for the network element) for the network element to the browser for display. The home page typically corresponds to the first hypertext document in the sequence in which the translated hypertext documents are accessed. As already noted, the sequence is determined by the designer of the page specification document.

However, in a typical environment, there are several network elements of several types, and all network elements of a given type can have one home page. Therefore, to determine the appropriate one of all the stored home pages to send to the browser, the network management station has to determine the type of the network element selected by the user. In one embodiment, the type of each network element is determined by sending an SNMP get packet with SysObjectID variable as is well known in the art. For each network element displayed, the network management station keeps track of the corresponding type. The network management station also keeps track of a corresponding home page for each type of the network elements. From this information, the network management station determines the appropriate home page from the user selected network element.

Thus, when a user clicks on the network element display, network management station automatically identifies the corresponding home page (hypertext document), and sends the document to the browser for display. The user merely has to click the hypertext links to access other hypertext documents and initiate network management actions.

However, when a user action causes the template to be displayed, the network management station needs to know the exact network element from which to retrieve data corresponding to the dynamic fields. The present invention enables this information to be provided transparent to the user as explained below.

5 When sending the home page and any subsequent hypertext pages as a user actuates the hypertext links, network management station encodes the IP address of the selected network element into the individual lines of the hypertext documents. The encoding is performed in such a way that the IP address is received as a parameter along with the URL, when the corresponding hypertext link is actuated. The network management station then retrieves the data dynamically from a network element with the received IP address, and sends the template including the retrieved data to the browser for display.

10 The present invention also provides the user the ability to view error conditions which may have occurred during a desired time period. To enable such capability, the present invention includes a process (e.g., Unix Daemon) executing continuously. The process receives reports of network events (e.g., SNMP traps) and stores them in non-volatile memory.

15 The user can view the traps conveniently from a Java Enabled Browser. Specifically, the present invention provides Applet modules on the central network management station and transfers the Applets to the user computer system upon a user request. The Applets are executed on the user computer system. The executed Applets interact with the daemons to display the error messages of interest.

20 Further features and advantages of the invention, as well as the structure and operation of various embodiments of the invention, are described in detail below with reference to the accompanying drawings. In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements. The drawing in which an element first appears is indicated by the leftmost digit(s) in the corresponding reference number.

25

What Is Claimed Is:

1. A method of managing a network comprising a plurality of network elements of a plurality of types, the method comprising the steps of:
 - storing a plurality of hypertext documents in a network management station, wherein said plurality of hypertext documents comprise at least one template, each template comprising a dynamic field identifying an information element of interest related to one of said types;
 - enabling a user to access the network management station using a browser;
 - sending an Applet module and data to said browser, wherein said data is representative of a network map of said plurality of network elements, wherein said browser executes said Applet module to display said network map;
 - receiving an indication of selection of one of said plurality of network elements from said browser, wherein said one of said plurality of network elements is selected by the user using said network map;
 - selecting a home page corresponding to said one of said plurality of network elements, wherein said home page is comprised in said plurality of hypertext documents, and wherein said home page includes a plurality of hypertext links;
 - enabling the user to access said plurality of hypertext documents by actuating said hypertext links provided in said home page;
 - receiving an identification of a template from said browser in response to said actuation of said hypertext link in one of said plurality of hypertext documents;
 - receiving an identification of one of said plurality of network elements from said browser;
 - assembling a simple network management protocol (SNMP) get packet specifying said information element of interest found in said dynamic field within said template;

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sending said SNMP get packet to the identified one of said plurality of network elements;

receiving data corresponding to said information element of interest; and displaying said template including the received data using said browser.

5 2. The method of claim 1, further comprising the step of enabling a designer to generate said plurality of hypertext documents, the step of enabling a designer comprising the steps of:

enabling the designer to specify a page specification document, wherein said page specification document includes statements to define the template and
10 to navigate between said plurality of hypertext documents; and enabling the translation of said page specification document into said plurality of hypertext documents.

3. The method of claim 1, further comprising the steps of:

sending an SNMP get request packet to request the type of the identified
15 one of said plurality of network elements; and receiving a response packet with an indication of the type of the identified one of said plurality of network elements, wherein said template is identified based on the indication of the type.

4. A method of managing a network comprising a plurality of network
20 elements of a plurality of types, the method comprising the steps of:

storing a plurality of hypertext documents in a network management station, wherein said plurality of hypertext documents comprise at least one template, each template comprising a dynamic field identifying an information element of interest related to one of said plurality of types;

25 enabling access of said plurality of hypertext documents from a browser; receiving an identification of a template from said browser in response to the actuation of a hypertext link in one of said plurality of hypertext documents;

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retrieving data corresponding to an information element of interest from one of said plurality of network elements; and
displaying said template including said data.

5 5. The method of claim 4, wherein said step of retrieving comprises the steps of:

assembling a packet according to a network management protocol standard, wherein said packet specifies said information element of interest comprised in said dynamic field included in said template;

10 sending said packet to said one of said plurality of network elements using said network management protocol standard; and
receiving said data corresponding to said information element of interest.

6. The method of claim 5, wherein said network management protocol standard is simple network management protocol (SNMP).

15 7. The method of claim 6, wherein said information element of interest is identified using a management information base object identifier (MIB OID).

8. The method of claim 5, wherein a home page is associated with each of said plurality of types.

9. The method of claim 8, further comprising the steps of:

20 sending an SNMP get request packet with SysObjectID to said one of said plurality of network elements; and

receiving a response packet with an indication of said type of said one of said plurality of network elements, wherein said home page corresponding to said one of said plurality of network elements is identified based on the indication of said type.

10. The method of claim 9, further comprising the step of maintaining a table indicative of association of each network element with a corresponding type, wherein each of said home pages is associated with a corresponding type.

11. The method of claim 5, wherein said information element of interest
5 comprises a row in a table.

12. The method of claim 5, further comprising said step of receiving a new value for said information element from a user, and altering the value on said one of said network elements with said new value using said network management protocol standard.

10 13. The method of step 6, further comprising the steps of:
providing an Applet module for generating a graphical display of a network;
transferring said Applet module to said browser;
executing said Applet module on said browser;
15 transferring to said browser a map representative of said plurality of network elements; and
displaying said map, wherein the user identifies said one of said plurality of network elements by selecting a portion of said map representative of said one of said network elements.

20 14. The method of claim 13, further comprising the steps of:
receiving an indication from said browser to perform topology discovery;
performing topology discovery in response to said received indication to determine said plurality of network elements present on said network;
sending a new map to said browser according to the determination; and

displaying said new map, wherein the user identifies said one of said plurality of network elements by selecting a portion of said new map representative of said one of said network elements.

15. A method of generating hypertext documents used for the
5 management of a plurality of network elements in a network, the method comprising the steps of:

providing a page specification document, wherein said page specification document includes statements identifying an information element of interest, an identifier for retrieving said information element, and a corresponding label; and

10 translating said page specification document into a plurality of hypertext documents including a template, wherein said template includes a dynamic field corresponding to said information element of interest.

16. The method of claim 15, wherein said information element of interest comprises a row in a table.

15 17. The method of claim 15, further comprising the step of enabling a designer to specify whether said information element of interest can be deleted or added or modified.

18. The method of claim 15, further comprising the step of enabling a designer to specify a function with said information element of interest, wherein
20 said function defines a manner of manipulating and displaying data retrieved corresponding to said information element of interest.

19. The method of claim 15, wherein said page specification document includes an assert statement to check whether an information element of interest on a desired network element is within a desired range of values.

20. The method of claim 15, wherein said page specification document includes an ensure statement to set a desired information element of interest to a desired value upon the indication of a user while managing the network .

5 21. A network management station for managing a network comprising a plurality of network elements of a plurality of types, said network management station comprising:

 means for accessing a plurality of hypertext documents comprising at least one template, each template comprising a dynamic field identifying an information
10 element of interest related to one of said plurality of types;

 a front end for communicating with a browser, wherein said front-end sends one of said plurality of hypertext documents to said browser and receives an identification of a template from said browser in response to the actuation of a hypertext link in one of said plurality of hypertext documents, said front-end
15 further receiving an identification of one of said plurality of network elements;
 a backend for communicating with each of said plurality of network elements; and

 a core for causing said backend to retrieve data corresponding to said information element of interest from said identified one of said plurality of
20 network elements, said core incorporating said retrieved data into said template and then causing said front-end to send the template to said browser, wherein said browser displays said template including said data in response to receiving said template.

25 22. The network management station of claim 21, wherein said core causes said front-end to send an Applet module and then a network map to said browser, wherein said browser displays said network map by executing the Applet module.

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23. The network management station of claim 22, wherein said core receives an indication of selection of one of said plurality of network elements in said network displayed by said browser, said core identifying a home page corresponding to said selected network element, wherein said plurality of
5 hypertext documents include said home page.

24. The network management station of claim 23, wherein said core sends said home page to said browser, and wherein said core receives an identification of another one of said hypertext documents in response to the actuation of one of
10 the hypertext links in the display of said home page by a user.

25. The network management station of claim 24, wherein said core encodes said identification of one of said plurality of network elements into each of said hypertext documents sent to said browser such that said identification of
15 one of said plurality of network elements is also received with each of said identification of each of said hypertext documents received from said browser.

26. The network management station of claim 25, wherein said backend uses simple network management protocol (SNMP) to communicate with said
20 plurality of network elements.

27. The network management station of claim 25, wherein said identification of each of said network elements comprises an Internet protocol network address.

25 28. The network management station of claim 25, wherein said front-end uses Hyper Text Transfer Protocol to communicate with said browser.

29. The network management station of claim 25, wherein said identification of each of said hypertext documents comprises a uniform resource locator.

30. The network management station of claim 25, wherein said dynamic
5 field comprises a management information base object identifier.

31. A computer program product for use with a computer system comprising a host processor, a main memory, a graphics controller, and a display unit, the computer program product comprising:

a computer readable program code means for causing the computer system
10 to enable a designer to provide a page specification document, wherein said page specification document includes statements identifying an information element of interest, an identifier for retrieving said information element, and a corresponding label; and

a computer readable program code means for causing the computer system
15 to translate said page specification document into a plurality of hypertext documents including a template, wherein said template includes a dynamic field corresponding to said information element of interest.

32. A computer program product for use with a computer system
20 comprising a host processor, a main memory, a graphics controller, and a display unit, said computer system being used to manage a plurality of network elements of a plurality of types, the computer program product comprising:

a computer readable program code means for causing said computer system to access a plurality of hypertext documents comprising at least one
25 template, each template comprising a dynamic field identifying an information element of interest related to one of said plurality of types;

a computer readable program code means for causing said computer system to communicate with a browser, wherein said front-end sends one of said

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plurality of hypertext documents to said browser and receives an identification of a template from said browser in response to the actuation of a hypertext link in one of said plurality of hypertext documents, said computer system further receiving an identification of one of said plurality of network elements;

5 a computer readable program code means for causing said computer system to communicate with each of said plurality of network elements; and

 a computer readable program code means for causing said computer system to retrieve data corresponding to said information element of interest from said identified one of said plurality of network elements, said computer system
10 incorporating said data into said template and then sending the template to said browser, wherein said browser displays said template including said data in response to receiving said template.

33. The network management station of claim 21, further comprising a computer readable program code means for causing said computer system to send
15 an Applet module and a network map to said browser, wherein said browser displays said network map by executing the Applet module.

34. The network management station of claim 22, further comprising a computer readable program code means for causing said computer system to receive an indication of selection of one of said plurality of network elements in
20 said network displayed by said browser, said computer system identifying a home page corresponding to said selected network element, wherein said plurality of hypertext documents include said home page.

35. The network management station of claim 23, further comprising a computer readable program code means for causing said computer system to send
25 said home page to said browser, and wherein said computer system receives an identification of another one of said hypertext documents in response to the actuation of one of the hypertext links in the display of said home page by a user.

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36. The network management station of claim 24, further comprising a computer readable program code means for causing said computer system to encode said identification of one of said plurality of network elements into each of said hypertext documents sent to said browser such that said identification of one of said plurality of network elements is also received with each of said identification of each of said hypertext documents received from said browser.

37. A method of managing error conditions in a network comprising a plurality of network elements, said method comprising the steps of:
configuring a network element to send indications of error conditions to
10 a network management station;
implementing a daemon to receive said indications of error conditions;
enabling access to said network management station from a browser;
sending one or more Applets to said browser, wherein said Applets when
executed provide an interface to display said error conditions; and
15 sending data representative of said error conditions from said daemon to
said executing Applets to display the error conditions to a user of said browser.

38. The method of claim 37, wherein said error conditions comprise SNMP traps.

39. The method of claim 37, further comprising the step of filtering said
20 error conditions before sending to said browser.

40. The method of claim 37, further comprising the step of filtering said error conditions in said browser to display the desired error conditions to said user.

41. The method of claim 37, wherein said browser maintains a permanent
25 connection with said network management station.

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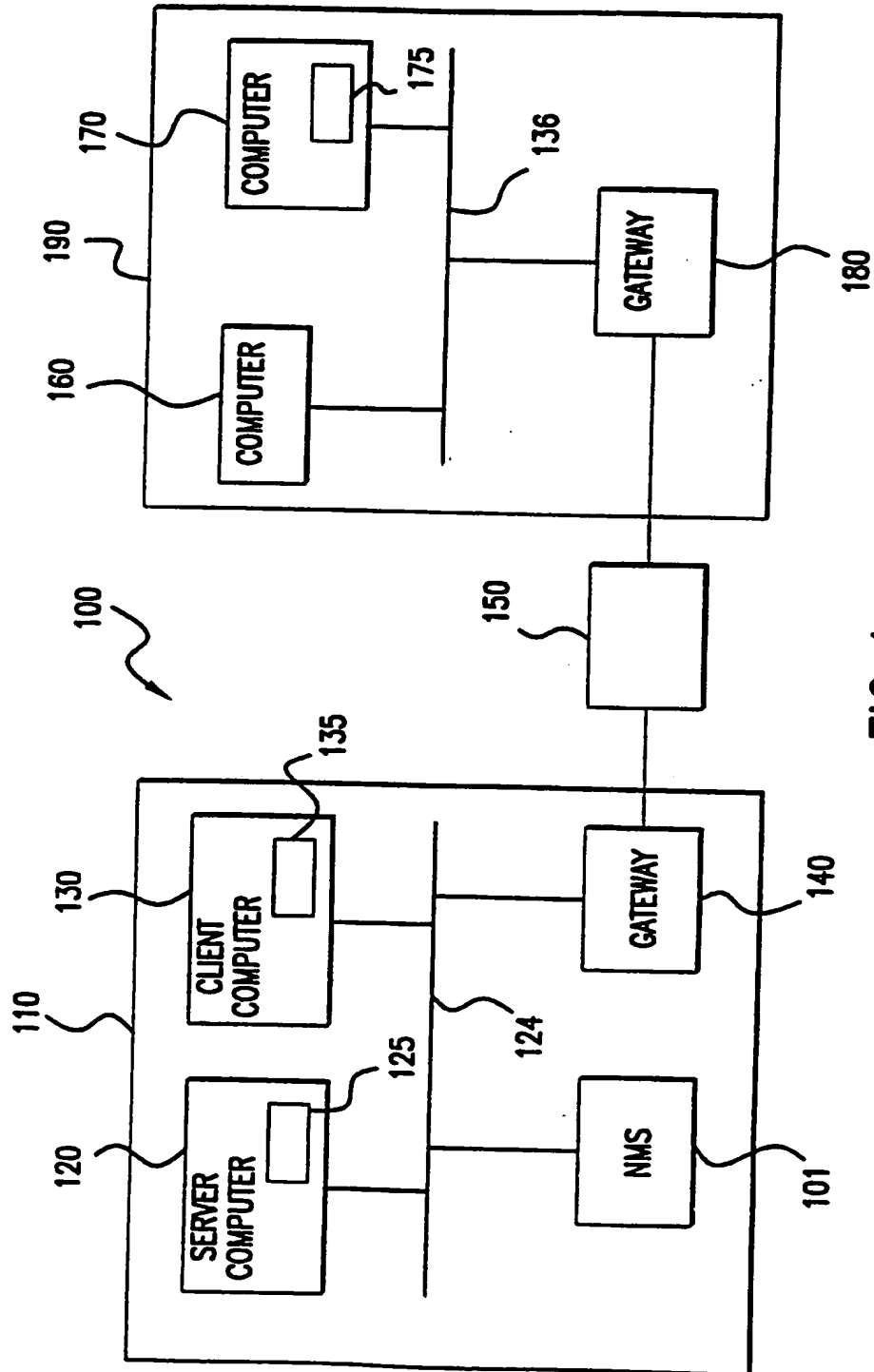


FIG. 1

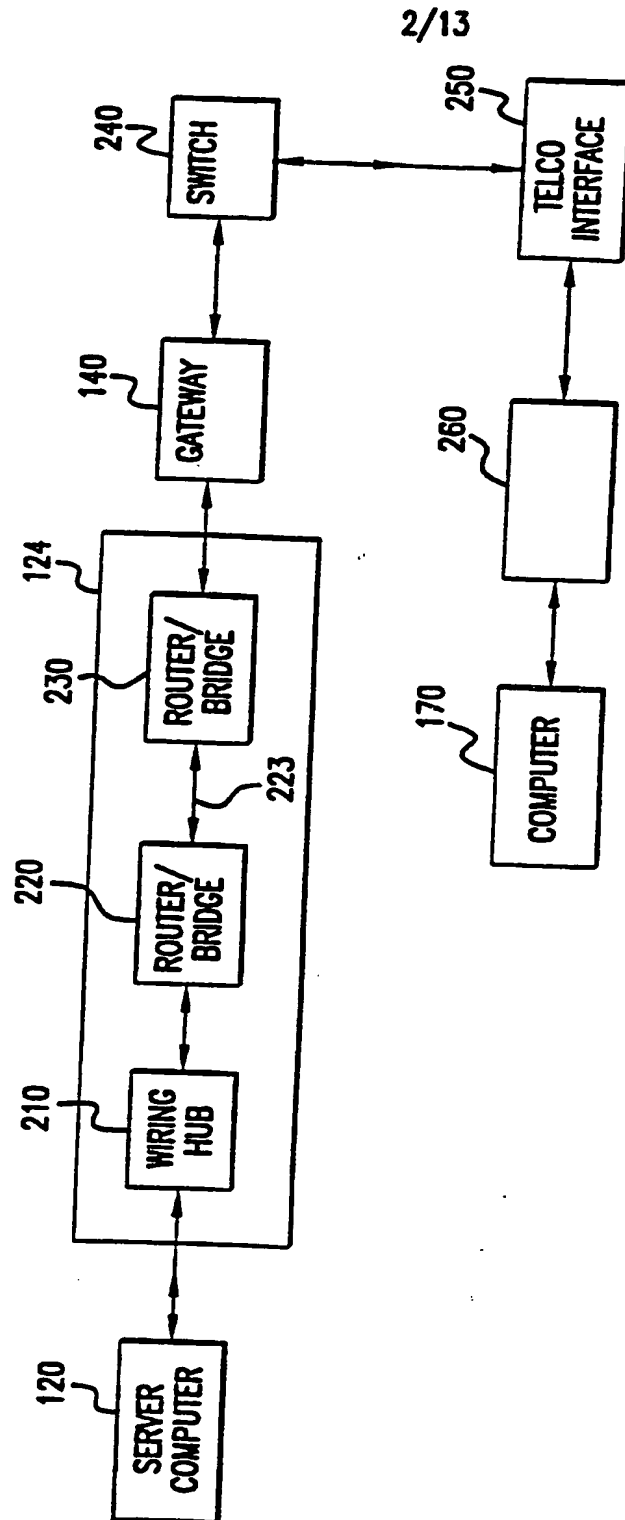


FIG. 2

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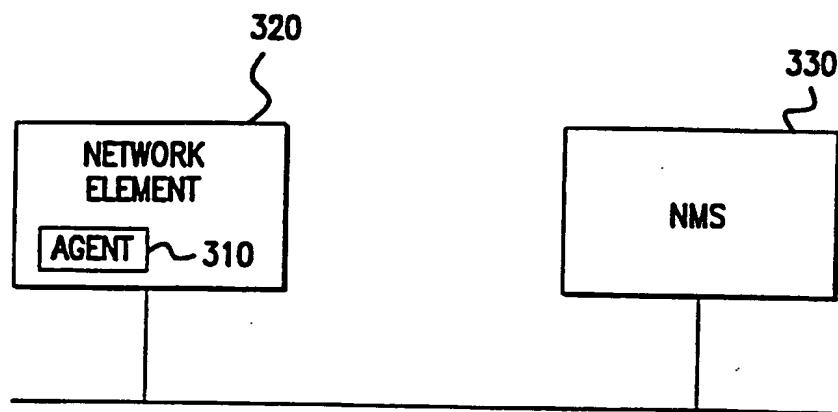


FIG. 3A

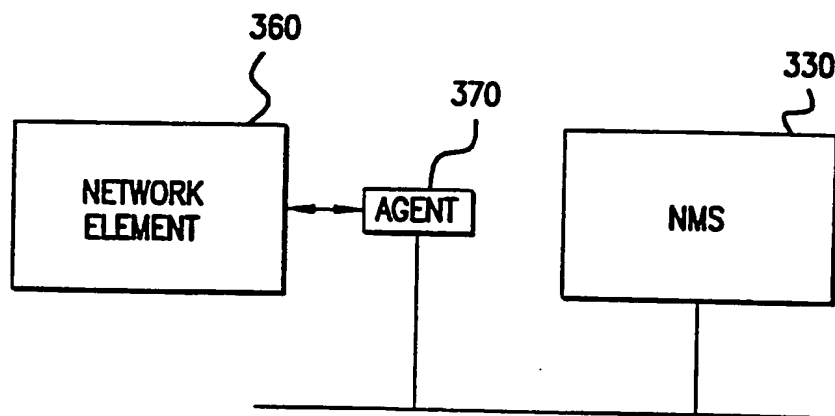


FIG. 3B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/09541**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :G06F 17/00

US CL :395/200.53

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 395/200.53, 200.54

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Service Level Management; "Netcool: creating order from Chaos", 1994.	1-41
A	Bay Networks; "Optivity Web", November 1996.	1-41
A	Product Catalog; "Cisco Rolls Out Innovation in Network Management", 6 June 1995.	1-41
X	Asante; "Intraspection", December 1996, see entire document.	1-41
A	US 5,426,421 A (Gray) 20 June 1995.	1-41
A	US 5,701,451 (Rogers et al.) 23 December 1997.	1-41

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